Fundamental Limits of Optical Patterned Defect Metrology

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ABSTRACT

This presentation will explore different optical technologies for extending high throughput defect inspection beyond the 22 nm node. The semiconductor manufacturing industry is now facing serious challenges in achieving defect detection rates with acceptable throughput and accuracy. With conventional bright field and dark field inspection methods now at their limits, metrology tool developers are exploring alternative optical methods such as angle-resolved scatterfield microscopy, 193 nm short wavelength solutions and coherent illumination. In this paper we will explore angle and polarization resolved illumination, measurement wavelengths down to 193 nm and interference microscopy using electromagnetic simulations and laboratory apparatus.

We will evaluate performance gains using scatterfield microscopy techniques for die-to-die defect metrology on 22 nm node layouts. Scatterfield microscopy enables design-specific bright field optical tools for use in signal-based defect analysis of features with dimensions well below the measurement wavelength. Central to this approach is engineering the illumination as a function of angle and analysis of the entire scattered field. This methodology has been applied to defect inspection for various defect types on intentional defect array (IDA) wafers.

Theoretical simulations will be reported using a fully three-dimensional finite difference time domain (FDTD) electromagnetic simulation package. Comprehensive modeling was completed investigating angle-resolved and polarization-resolved illumination to enhance defect detection for a 13 nm linewidth logic-poly stack. Oblique incidence is compared against more conventional illumination. Angle and polarization resolved enhancements and defect sensitivity gains are identified and presented.

Comprehensive modeling to investigate a range of illumination wavelengths to enhance defect detection for several defect types has also been completed. Simulation results will be shown that evaluate performance gains obtained at wavelengths ranging from 193 nm to 450 nm. The data show that many defects are more detectable when using the shorter 193 nm or 266 nm illumination wavelength. However, an optimum wavelength between $\lambda = 193$ nm and $\lambda = 266$ nm cannot be identified without consideration of the process stack, materials, defect type and directionality, incident angle, and polarization. We will present 193 nm Scatterfield Microscope imaging results on an IDA 65 nm logic-poly stack. Experimental efforts are focused toward the validation of simulation results, essential for confirming and optimizing shorter measurement wavelength and oblique illumination performance gains for some process stacks and to provide direction for the extensibility of optical defect detectability.

This paper will also look at emerging approaches using interference microscopy. Recent results show that using optical interference techniques may be another avenue to improve sensitivity to defects. An FDTD model has been modified to allow rigorous simulation of interference microscopy applied to defects.

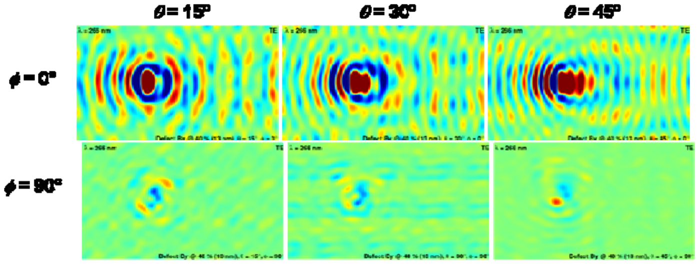

FIGURE 1. Simulated differential images for a 13 nm bridge defect as a function of incident angle for $\lambda = 266$ nm.